COLUMBIA UNIVERSITY

EARTH ENGINEERING CENTER

Advancing Sustainable Waste Management

Report from visit of Dr. A.C.(Thanos) Bourtsalas and ten EEE graduate students to WTE facility in West Palm Beach, Florida, May 2016

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1. General information

Early in 2004, the West Palm Beach Authority initiated an update to its twenty-year master plan to insure that its integrated solid waste management system would continue to meet the recycling and waste disposal needs of Palm Beach County. This plan ultimately included the refurbishment of the existing 2000 tons per day (TPD) refuse derived fuel (RDF) waste to energy facility, commissioned in 1989, and the expansion of the waste to energy (WTE) processing capacity. In October 2008, after an extensive evaluation, the Authority Board approved the development of the REF#2, which is a 3000 TPD mass burn facility, which was completed in July 2015. The total project cost was $672,000,000 or $672 per ton of capacity. The project was completed on budget and on schedule, and represents the largest WTE project in the US. It produces 575 KWh of electricity per ton of processed waste with a total revenue from the selling of electricity of $18MM/yr.

REF#2 is situated just to the North of its sister facility REF#1. The total site area currently occupied by REF#2 is about 30 acres. Of this area approximately 20% of the site was created by filling a lake, this reclaimed land required dynamic compaction to insure that it could support the infrastructure planned for these areas. There were many unique features added to the design in an effort to reduce the visual impacts of the facility. These include the curved roof lines, and bold color scheme. One of the most unique is the oval shaped stack. At 310 feet high and 25 feet across, the stack is the most prominent feature of the facility, containing three (3) flues one for each of the boilers as an integral component of the Air Pollution Control system. The oval shape was conceived to provide a reduced profile when viewed from the North/South directions. The slimmed profile of the stack along with the addition of landscaping near the community just to the North serves as an effective screen.

The REF#2 is made up of a complex of eleven buildings totaling over 266,000 square feet. All aspects of the operation were housed, from administrative to electrical generation. Notably, the detailed road network and traffic control plan are designed to efficiently handle numerous vehicle types including waste delivery, employees, visitors and supply delivery vehicles.

2. Tipping building

The tipping building at 57,774 square feet is designed to handle up to 24 delivery vehicles at any given time. The waste is delivered to the facility primarily by the Solid Waste Authority (SWA) fleet of over 80 tractor trailers which operate out of the system of six Transfer Stations, which were strategically located geographically throughout the county, and allow SWA to more efficiently move the waste from collection to the ultimate disposal site.

3. Waste Storage Building

The waste storage building has a projection of 58,946 square feet, pit volume of 1,131,500 cubic ft. (100’x365’x31’) to tip floor elevation 54’. D; size of the feed chutes is 37’10”x41’7”x8’1”. Manufactured by KONE, each of the cranes inside the storage building is 16 tons with a capacity of 245 Tons/hr. Every crane is equipped with orange peel style grapples with a capacity of 15.7 cy/7.4 tons, uses sensors to accomplish stacking, sorting and feeding in semi-automatic and automatic modes, and is manually controlled from joy stick in Operating Chair in Control Room.

4. Boiler Building

The boiler building is 32,784 SF, main facilities include the boiler, feed water pumps, grate system, ash expellers, diverter gates, vibrating conveyors, and inclined conveyors.

There are three B&W Stirling Power Boilers with natural circulation in total, main components of the boiler include waterwall furnace, pendant super heaters, generating bank, and economizer. The tube size is 2.5" OD on 3.0" center, the waterwall heating surface is 10,536 SF., 70 mil inconel 625 overlay, the furnace volume is 67,700 cubic feet. The waste feed rate: 41.67 tons/hr on average, 1000 ton/day, and this is the minimum throughput guarantee. Waste can get adjusted up to 1100 ton/day depending on fuel quality. After fed, the residence time of the waste is controlled by the furnace volume design. The furnace temperature is approximately 2000 deg F; flue gas temps through the superheater bank is about 1226 Deg F, flue gas temps through the steam generating bank is about 810 Deg. F, while that through the economizer is about 520 Deg F. The steam temperature is 830 Deg F, pressure is 900 psig, #/hr is 284,000 #/hr at MCR condition.

The three feed water pumps are manufactured by KSB, two of them are 100% capacity, the other one is electric driven dribble pump. Flow rate in the pumps is 2,400 GPM at 3000 Ft TDH, the FW temperature is 300 Deg F.

The grate system is manufactured by B&W Volund using the material EN 10295 Werkstoff 1.4826 GX40CrNiSi22-10, and is in the form of wave grave, which is a series of grate bars that rock up and down in sequence along the grate mimicking a rolling wave, thus moving the fuel down the inclined grate. Size of the grate system is 1,395 SF /boiler, and is made up of 4 sections on each of the 2 sides, all independently speed adjustable. Position of the grate is downward slope at 25 degrees.

Each boiler has two ash dischargers, as well as two diverter gates. The ash expellers are made by B&W Volund, and are made of steel plate, consist of a rear end with a pusher piston and an outlet chute. The internal surfaces subject to wear and tear are made of replaceable wear plates. The diverter gates are manufactured by Material Handling Equipment (MHE), and are designed to discharge into either of the redundant vibrating conveyors.

The vibrating conveyors are manufactured by GK, they convey bottom ash from boiler expeller to an inclined sloped belt conveyor system and ultimately to Ash Management Building. There are two vibratory conveyor systems in total, and are at 1% negative slope each with a capacity of 90 tons/hr.

The inclined conveyors are an inclined belt conveyor system with a 90 ton/hr capacity. This system is approximately 145 ft long, at 14 degrees' incline, 20 hp drive motors.

5. ACC – Air Cooled Condenser

The Air Cooled Condenser(ACC), manufactured by SPX Cooling Technologies, has a heat exchanger surface area of 5,630,000 SF. Force draft, A frame (Aluminum fins), single row condenser, three streets; # of fans: 15 total (5 per street), dual speed design. The flow rate is 675,300 #/hr, efficiency: 35°F approach. It saves 540 million gallons of water per year.

6. APC Building

The APC building consists of a Spray Dryer Absorber(SDA), a Pulse Jet Filter Fabric(PGFF) System, a Gas to Gas Heat Exchanger, a Selective Catalytic Reduction System(SCR), ID fans, and a Continuous Emission Monitoring System(CEMS).

The spray dryer absorber (SDA) has been designed to reduce the emissions of hydrogen chloride (HCl), hydrogen fluoride (HF), sulfur dioxide (SO_2) and sulfurtrioxide/sulfuric acid mist (SO_3/H_2SO_4). Absorption of acid gases primarily occurs as the flue gas is cooled adiabatically by the evaporation of the water contained in the atomized spray. The finely atomized feed slurry (from a Rotary atomizer) mixes with the flue gas, resulting in the vaporization of water and the removal of the acid gases via chemical reaction with the slurry. The operating temperature of the absorber should be 450 deg F inlet temperature, the flow rate is 197,900 ACFM, rotary atomizer. It reaches an efficiency of 95%.

Pulse Jet Filter Fabric (PJFF) System contains 8 Modules per unit, traps airborne particles in 6" diameter, 26 ft. long Fiberglass Filter bags from a flow rate of 190,000 ACFM. There are 221 bags per module. The entrapped particles are removed via pulses of compressed air when a predetermined pressure drop is detected across the filters. The removed material is collected at the bottom of the modules and discharged into the fly ash conveyor system. Operating temperature of this system should be 500 Deg F maximum.

The GtG Heat Exchanger is shell and tube type, with a flow rate of approximately 150 Kscfm. Average gas temperature leaving heat exchanger A is 335 deg F, average gas temperature leaving heat exchanger B is 350 deg F, average gas temperature entering SCR is 475 deg F.

The Selective Catalytic Reduction(SCR) System is located downstream on the cold side (tail end/post acid gas and particulate control) system, the catalyst equipped in which is extruded homogenous honeycomb uses ammonia as a reagent. Its location maximizes the longevity of the catalyst by not exposing it to poisons, eliminating plugging and ammonia salts masking of the catalyst. In addition, a honeycomb style catalyst is used to minimize fouling. This system is sized for additional future expansion if needed. It incorporates the latest catalyst technology to remove Nitrogen Oxide, and it requires the flue gas to be reheated prior to entering the SCR which is accomplished by steam extraction and a gas to gas heat exchanger prior to entering the SCR. The flow rate of the gas is about 215,000 ACFM, operating temperature between 450 and 700 deg F.

The centrifugal, double wide double inlet ID fans are manufactured by Clarage. HP: 2,500 HP, variable speed drive, 1190 RPM. Flow rate: 244,700 ACFM

Continuous Emission Monitoring System required by Title V Permit to continuously measure and record the quantity of regulated pollutants emitted from the Boiler Stack. The system monitors boiler exits flue gas (untreated gas at the inlet of the SDA) and treated flue gas at the ID fan inlet (i.e. after the SDA, fabric filter and SCR). The pollutants that are continuously monitored include carbon monoxide (CO) at the SDA inlet and sulfur dioxide (SO2), nitrogen oxides (NO3) and opacity at the ID fan inlet. However, the actual permit limits for pollutants are: NOx 50 ppmvd, CO 100 ppmvd, SO2 24 ppmvd, Opacity 10%.

7. Turbine/Generator Building

The Multi stage Axial Exhaust Steam Turbine Generator is manufactured by GE, and is designed to convert the energy recovered from the solid waste fuel burned in the Boiler (converted to superheated steam) into saleable electricity. Superheated steam enters the turbine at high pressure through the inlet control valves and exhausts through the last stage of rotating blades and into the steam piping manifold to the ACC. The superheated steam is converted into a mechanical shaft power in the steam turbine, which is then converted to electricity in the Generator. The electricity is then transfer to the utility via transmission lines. The generator is 142,500 KVA nameplate rating, 96.6 MW rated capacity. 13.8 KV, Turbine: 14 stages. 870 psig/825 Deg F. 852,000 lb/hr.

There are extraction ports of intermediate and low pressure steam. The extracted steam is used by the low pressure feed water heater, deaerator and steam coil combustion air pre-heaters. The low pressure feed water heater heats condensate from the ACC to increase the cycle efficiency. The deaerator tank is used to continue to heat the condensate and to remove non condensable gases to prevent corrosion. The Steam coil air heater is used to pre heat the combustion air to the boiler to increase cycle efficiency.

8. Ash Management Building

The ash management building is 41,654 SF; its throughput is 900 TPD. Fly ash is collected from the bottom of the economizer and the APC building (SDA's and Baghouses) and transported via drag chain closed conveyor system to a fly ash silo in the Ash Management Building. From the silo, the fly ash is conditioned in a pug mill, then discharged into an ash bunker. Bottom Ash is collected, quenched and dewatered from the bottom of the boiler grates prior to discharging on to the vibratory conveyor system. From the vibratory system the bottom ash is conveyed into the Ash Management Building via an inclined belt conveyor. From the belt conveyor system, the bottom ash falls onto a primary or redundant grizzly scalpers that separates the bulky material (>6") from the bottom ash stream. The bulky material falls on to the floor of the Ash Management Building. The remaining bottom ash stream is then conveyed to the metals recovery equipment. Ferrous removal through a Rotary Drum Magnet which designed to lift 90% or more of the incoming Fe material. Recovered FE metals are then conveyed and deposited in the Fe metal bunker. The bunker is designed to store up to 5 days of collected metals from the facility running at full capacity. Non Ferrous metals are separated via Eddy Current Separator (ECS) designed to separate up to 85% of materials larger than 3/8". The separated Non Fe materials are deposited in a Non Fe bunker designed to store up to five (5) days of collected non-ferrous metals. The balance of the bottom ash is deposited into the ash bunker. The ash bunker is sized to store up to 4 days of collected ash material from the facility running at full capacity.

9. Water Supply and Treatment

The water needs associated with power generation are significant both in terms or quantity and quality. One of the main design challenges for this project was meeting those needs without any additional groundwater withdraw. This was achieved by incorporating several unique features, the first of these is a rainwater harvest and recycling system which is designed to collect the first two (2) inches of rainfall from the extensive roofing systems throughout the facility and store it in a two (2) million gallon recycled water

storage tank. This combined with boiler blow down from the existing facility REF#1 and the recycled water from the air cooled condensing system (ACC) supply the majority of the process water needed for the facility. The water is treated primarily by an RO system designed to meet the quality requirements for steam production. The LEED platinum designed Education Center has a separate 12,000-gallon cistern which captures rain and supplies water for irrigation of the roof garden area.

The treatment system is manufactured by GE Water & Process Technologies, type is Model RO, Pro E Cell NA-100 DP, Reverse Osmosis system. The permeate rate is 136 GPM, concentrate rate is 45 GPM. Activated carbon filters on inlet water supply. 2M gallon tank dimensions: 105’ ID x 30’11” WD

10. Educational center

West Palm Beach WTE plant has one of the most advanced educational centers in the world. Touch screens are provided, where visitors are called to play games relevant to separation of waste streams and identification of the recyclable materials.